

Quality Report SQAS94-001

## **Status of Licensing and Certification of Software Professionals**

**November 1994**

**Software Quality Assurance Subcommittee  
of the  
Nuclear Weapons Complex Quality Managers**

**United States Department of Energy  
Albuquerque Operations Office**

### **Abstract**

This report presents information on existing and proposed software engineering certification programs, licensing of software engineers, reasons to become certified, certification as a condition of employment, the body of knowledge and examination structures for the certification programs, and an overview of the Institute of Electronic and Electrical Engineers recommendations for software engineering as a profession.

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## **ACKNOWLEDGEMENT**

The Software Quality Assurance Subcommittee of the Nuclear Weapons Complex Quality Managers initiated Work Item #12 to research software-related certification and licensing efforts and to provide periodic status reports to the Quality Managers. This document is a significant result of that work item and establishes the baseline for periodic status reports. The working group and other major contributors to this document are listed below.

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## EXECUTIVE SUMMARY

Certification is a voluntary process administered by a professional society. Licensing is a mandatory process administered by government. Three professional organization have been identified as having or developing certification programs, and one state has developed legislation for a licensing program:

- The Institute for Certification of Computer Professionals (ICCP) has two levels of certification Associate Computing Professional, and the Certified Computing Professional;
- The American Society for Quality Control has completed Draft 5.8 of its certification program for Software Quality Engineer;
- The Software Quality Systems Registration Committee of the U. S. Registrar Accreditation Board (RAB) is considering a program for ISO 9000 Accreditation for Software Auditor;
- New Jersey is the only state identified as actually enacting software development legislation, their licensing program covers "software designers".

Members of the SQAS Work Item 12 Group tried to determine Software Engineering or Development licensing efforts in their respective NWC states; however, no evidence was found to document licensing efforts in these states.

The certification programs are presented as confidence-building proof that an individual has met specific requirements and possess high levels of knowledge and skills. It is noteworthy and appropriate that in the "bodies of knowledge" presented in the certification programs that only the ICCP Associate Computing Professional had examination requirements for specific programming languages. That is, the emphasis is on the rigors of software engineering and software management processes.

It is recommend that certification not be used as a condition of employment. Equal Employment Opportunity (EEO) laws are detailed regulations published by the federal government which control the employer's use of selection procedures and if procedures (such as written tests) affect designated population subgroups, then the employer must have substantial evidence that the procedure meets a business necessity.

The Institute of Electrical and Electronic Engineers' Steering Committee Report, "Establishment of Software Engineering as a Profession", contained four recommendations: Adopt Standard Set of Definitions; Define Required Body of Knowledge Recommended Practices; Define Ethical Standards; and Define Educational Curricula.

## 1. INTRODUCTION

Licensing is a mandatory process administered by government and certification is a voluntary process administered by a professional society; that is:

**Certification:** Formal recognition granted by a profession that an individual has demonstrated a proficiency within, and a comprehension of, a specific Body of Knowledge at a point in time.

**License:** Permission granted by a government authority to an individual to engage in a business or occupation or in an activity otherwise unlawful.

This report presents information on licensing and certification of software engineers and developers, and "software engineering as a profession":

- Existing and proposed software engineering certification programs;
- Licensing of software engineers;
- Reasons to become certified;
- Certification as a condition of employment;
- Body of knowledge and examination structures for the certification programs;
- An overview of the Institute of Electronic and Electrical Engineers recommendations for software engineering as a profession.

Included in this paper are considerations and implications for licensing and certification. What incentive is there to become certified? What evidence is required to prove that there is no discrimination with regard to equal employment opportunity laws and with respect to certification as a condition of employment?

## 2. SOFTWARE QUALITY AND SOFTWARE ENGINEERING CERTIFICATIONS

### **Established Program**

#### Institute for Certification of Computer Professionals (ICCP)

Associate Computing Professional (ACP)  
Certified Computing Professional (CCP), effective 1/1/94

Before 1/1/94, the following designations were offered:  
Certified Computer Programmer (CCP)  
Certified Data Processor (CDP)  
Certified Systems Professional (CSP)  
Associate Computer Professional (ACP)

### **Programs Being Proposed or Developed**

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American Society for Quality Control (ASQC) Draft 5.8  
Software Quality Engineer

Software Quality Systems Registration (SQSR) Committee of the U. S. Registrar Accreditation Board (RAB). U. S. Accreditation Requirements for ISO 9000 Software Auditors using United Kingdom "TickIT" program as the model.

ISO 9000 Accreditation for Software Auditor

### **3. LICENSING OF SOFTWARE ENGINEERS**

Gary Ford, SEI Technical Staff, presented a paper at the 1993 SEI Software Engineering Symposium entitled, "The Current State of Certification & Licensing of Software Engineers". This paper contained excerpts on professional licensing from three states: Pennsylvania, West Virginia, and New Jersey. **New Jersey** was the only state identified as actually enacting software development legislation (State of New Jersey, Assembly Bill 4414, New Jersey Software Designers' Licensing Bill).

#### **MOTIVATION FOR LICENSING ENGINEERS**

Pennsylvania Statute, "...to safeguard life, health or property and to promote the general welfare..."

West Virginia Statute, "...to safeguard life, health or property and to promote the public welfare..."

New Jersey Statute, "... the public interest requires the regulation of the practice of software designing and the establishment of clear standards for software designers, and the welfare of the citizens of this State will be protected by identifying to the public those individuals who are qualified and legally authorized to practice software designing."

#### **LICENSING ENGINEERS IN OTHER STATES**

Members of the SQAS Work Item 12 Group tried to determine Software Engineering/Development licensing efforts in their respective NWC states: California, Colorado, Florida, Missouri, New Mexico, Ohio, South Carolina, Tennessee, and Texas. However, no evidence was found to document licensing efforts in any of these states.

## **4. WHY BECOME CERTIFIED?**

### **ASQC:**

- In today's world where quality competition is a reality, and the need for high-quality software a central concern of many organizations, certification serves as a mark of excellence by demonstrating that the certified individual has the knowledge needed to improve the quality of software. Over 125 organizations have formally recognized ASQC Certification as verification of an individual's possession of this knowledge. Certification is an investment in your career and in the future of your employer.

### **ICCP:**

- There is no doubt: Certification is the way to the top of the computing profession. And the prestigious CCP designation...Certified Computing Professional...from ICCP is recognized worldwide by employers and peers as validation of its holders' computing knowledge and experience.
- The CCP is the standard which others covet. That is because ICCP, the Institute for Certification of Computing Professionals is acknowledged throughout the information and technology sectors as the most important source of professional certification. Our CCP examination demands a high degree of professional competence from those who pass; consequently, the designation is powerful evidence of the high level of attainment of a true Certified Computing Professional.
- It should be no surprise, therefore, that the ICCP is the standard in professional certification for 22 national and international professional computing societies - and for numerous individual employers.
- Certification is the confidence-building proof that you have met specific requirements and possess high levels of knowledge and skills. And it is easier than ever to become certified, with the introduction of our innovative computer-based testing concept.
- In tough economic times, certification adds to your professional credibility and gives you an advantage in the competitive job market. The recognition that comes with the CCP designation makes ICCP the industry's leading professional certification organization.



## **5. CERTIFICATION AS A CONDITION OF EMPLOYMENT**

Equal Employment Opportunity (EEO) laws are detailed regulations published by the federal government which control the employer's use of selection procedures:

If procedures (such as written tests) affect designated population subgroups, then the employer must have substantial evidence that the procedure meets a business necessity. With paper and pencil tests, adverse effect will normally be assumed unless the employer has evidence to the contrary since the results of most tests do differ among population subgroups. Most tests used in education and employment show differences among population subgroups.

An employer has one of two ways to show the procedure or test measures skills about the job in question:

1. Offer statistical evidence, usually correlations between test scores and measures of actual job performance which show that higher scores are linked to higher levels of performance.
2. Show that the content of the exam covers specific job skills which are essential to the job in question.

## **6. OVERVIEW OF THE ICCP REQUIREMENTS FOR ASSOCIATE COMPUTING PROFESSIONAL**

**Experience:** Any person who has obtained basic knowledge of Information Processing and one of the recognized programming languages may apply for the exam.

**Examination:** Pass a two-part examination,

- 1) Core Examination
- 2) Option of one of eight programming languages: Ada, BASIC, C, COBOL, Fortran, Pascal, RPG II, and RPG/400.

**ICCP Codes:** Candidates must subscribe to Code of Ethics, Conduct and Good Practice.

## **7. OVERVIEW OF THE ICCP REQUIREMENTS FOR CERTIFIED COMPUTING PROFESSIONAL**

**Experience:** 48 months of full-time (or part-time equivalent) professional experience. A bachelor's or graduate degree in IS or CS or an ACP Certification may be counted as 24 months experience. A bachelor's or graduate degree in a related field may be counted as 18 months experience. A bachelor's or graduate degree in an unrelated field may be counted as 12 months experience.

**Proof of professionalism:** Statements from professional colleagues attesting to experience and qualifications.

**Examination:** Pass a three-part examination,

- 1) Core Examination
- 2/3) Two Specialty Examinations: Management, Procedural/Programming, Systems Development, Business Information Systems, Communications, Office Information Systems, Systems Security, Software Engineering, Systems Programming, and Data Resource Management.

## **8. OVERVIEW OF THE PROPOSED ASQC REQUIREMENTS FOR SOFTWARE QUALITY ENGINEER**

**Experience:** 8 years of professional experience. A graduate degree may be counted as 5 years experience. A bachelor's degree may be counted as 4 years experience. An associate degree may be counted as 2 years experience. A technical school certificate may be counted as 1 years experience.

**Proof of professionalism:**

Membership in appropriate society or,  
Registration as a Professional Software Engineer or,  
Statements from two professional colleagues verifying that you are a qualified practitioner of software quality engineering.

**Examination:** Pass a two-part examination,

- 1) Software Quality Engineering Principles
- 2) Software Quality Engineering Applications

**ASQC Code:** Successful candidates agree to abide by the ASQC Code of Ethics.

**9. OVERVIEW OF THE PROPOSED SOFTWARE QUALITY  
SYSTEMS REGISTRATION (SQSR) REGISTRAR  
ACCREDITATION BOARD (RAB) REQUIREMENTS FOR ISO 9000  
SOFTWARE AUDITOR**

Experience: To be determined

Possess a minimum number of years experience in software development.

Possess a minimum number of years experience in software quality management systems.

Proof of professionalism: Pass a RAB conducted technical interview process.

Examination: Pass a RAB-accredited lead auditor course.

ICCP Codes: Candidates must subscribe to Code of Ethics, Conduct and Good Practice.

**10. ICCP ASSOCIATE COMPUTING PROFESSIONAL & CERTIFIED  
COMPUTING PROFESSIONAL EXAMINATION STRUCTURE**

**CORE EXAMINATION**  
(Mandatory for Both Exams)



Human and Organization Framework  
Systems Concepts Technology  
Data and Information

Systems Development  
Associated Disciplines

### **Examination Information**

The examination consists of 66 questions and lasts 1 1/2 hours. Associate Computing Professional Candidates must pass the examination with a minimum score of 50%. Certified Computing Professional Candidate must pass the examination with a minimum score of 70%.

## 10.1 ICCP ASSOCIATE COMPUTING PROFESSIONAL LANGUAGE EXAMINATION STRUCTURE

(choose one language examination for ACP designation)

### **Ada**

Lexical Elements  
Declarations and Types  
Names and Expressions  
Statements  
Subprograms  
Packages  
Tasks  
Input and Output  
Other Topics

### **C**

Data Types  
Operators and Expressions  
Control Flow  
Functions  
Pointers and Arrays  
Structures and Unions  
Standard I/O Library  
Library Functions and Environment  
The Preprocessor

Elementary Topics  
Procedures and Functions  
Control Structures  
Defined Data Types  
Arrays  
Recursion  
Text Files  
General Files  
Records  
Pointers

### **COBOL**

General  
Compiler Commands  
Divisions and Sections  
Debugging

### **BASIC**

Characteristics of a BASIC Program  
Data  
Expressions and Assignments  
Input and Output  
Control Statements  
Functions  
Arrays  
String Manipulation

### **RPG/400**

General Topics  
Data  
File Processing  
Calculation Operations  
Arrays and Tables  
Program Control  
Debugging

### **RPG II**

Specification Types  
Editing  
Calculations  
File Concepts  
Control Levels  
Logic Control  
Matched Records  
File Organizations  
Tables  
Arrays  
Logic Cycle  
Debugging

### **Fortran**

Fortran Terms and Concepts  
Implementing Control Structures  
in Fortran  
Implementing Data Structures  
in Fortran  
Manipulating Data  
Input and Output

### **Pascal**







## 10.2 ICCP CERTIFIED COMPUTING PROFESSIONAL EXAMINATION STRUCTURE

(Choose two from following section for CCP designation)

### **Management**

General Management and  
Organizational Concepts  
Project Management  
Information Systems  
Management

### **Data Resource Management**

Data Resource Management  
Functions  
Data Analysis  
Data Base Design

### **Systems Development**

System Analysis  
System Design and  
Implementation  
The Systems Analyst  
as a Professional

### **Software Engineering**

Computer System  
Engineering  
Software Project Planning  
Software Requirements  
Software Design  
Programming Languages  
and Coding  
Software Quality Assurance  
Software Testing Techniques  
Software Maintenance and

### **Systems Programming**

Languages  
Operating Systems  
Language Processing  
Concurrent and Distributed Processing  
Data Management Systems  
Computer Architecture and  
Implementation  
Performance Evaluation  
Software Tools  
Systems Management

### **Communications**

Data Communications  
Theory  
Networking Theory  
The ISO OSI Reference  
Model  
Established Communications  
Systems  
Hardware  
Usage and Design  
Configuration Management

### **Business Information Systems**

BIS Applications  
The BIS Environment  
BIS Considerations

### **Procedural Programming**

Data and File Organization  
Program Design  
Procedural Program Structure  
Procedural Programming  
Considerations  
Integration with Hardware and  
Software

### **Systems Security**

Risk Assessment  
Recovery from Information  
Service  
Interruptions  
Information and System Security  
Security in System Design  
Security Management

### **Office Information Systems**

Office Environment  
Office Technologies  
End User Computing



## 11. ASQC SOFTWARE QUALITY ENGINEER PROPOSED BODY OF KNOWLEDGE

### Software Quality Management

- A. Software Total Quality Management
- B. Software Quality Planning
- C. Participation
- D. The Software Quality Function
- E. Quality Information Systems
- F. Quality Management Tools
- G. Quality Education and Training
- H. Professionalism

### Software Engineering

- A. Basic Concepts
- B. Software Engineering Techniques
- C. Software Engineering Life Cycle

### Project Management

- A. Planning and Control
- B. Managing People

### Appraisal

- A. Software Inspections
- B. Testing
- C. Verification and Validation
- D. Assessments, Audits, and Reviews

### Issues

- A. Controls
- B. Data Integrity
- C. Disaster Planning
- D. Liability
- E. Maintainability
- F. Reliability
- G. Risk Management
- H. Safety
- I. Security

### Analytical Methods

- A. Metrics and Measurement
- B. Probability and Statistics
- C. Statistical Process Control

### Quality Systems

- A. Software Corrective Action
- B. Software Configuration Management
- C. Software Standards and Procedures
- D. Improvement and Innovation
- E. Software Quality Function Deployment
- F. Procurement

### Examination Information

The Software Quality Engineering Principles exam and Software Quality Engineering Applications exam consist of multiple choice questions. Each exam lasts 3 hours. Candidates must pass both exams to be certified.

## **12. INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE) OVERVIEW**

### **Steering Committee Report, "Establishment of Software Engineering as a Profession"**

- \_ Recommendation 1: Adopt Standard Set of Definitions.
- \_ Recommendation 2: Define Required Body of Knowledge Recommended Practices
- \_ Recommendation 3: Define Ethical Standards
- \_ Recommendation 4: Define Educational Curricula

#### **12.1 IEEE RECOMMENDATION 1: Adopt Standard Set of Definitions.**

We recommend the adoption of a standard set of definitions. IEEE Standard 610.12 is good starting place (610.12-1990 IEEE Standard Glossary Software Engineering Terminology). Other standard glossaries might be appropriate but in any event, these definitions should be carefully examined for appropriateness and scope. This task could be entrusted to the Standards Activities Board of the Computer Society and the appropriate Standards Subcommittee(s).

#### **12.2 IEEE RECOMMENDATION 2: Define Required Body of Knowledge Recommended Practice**

We recommend the identification of a required body of knowledge and recommended practices (in electrical engineering, for example, electromagnetic theory is part of the body of knowledge while the National Electrical Safety Code is a recommended practice.) The required body of knowledge and recommended practices are not static because technology evolves and the professionals should keep up with the field. This activity should be entrusted to a task force of industry experts. Industry should lead the effort because employers know what their software engineers do well, poorly, or indifferently.

Adoption of new practices often requires cultural changes and these processes take years to accomplish. Thus, the initial set of recommended practices ought to be modest and easily achievable. The development and maintenance of the set of recommended practices should be structured like a technical standard: adopted by consensus and subject to periodic revision.

We should not confuse organizational practices with individual practices. Organizational maturity is already the subject of a healthy activity by Software Engineering Process Groups (SEPGs) and Software Process Improvement Networks (SPINs). Industry is adopting standards to assess and improve organizational maturity (ISO 9000, SEI CMM) and we should capitalize on these developments but not confuse the issues.

Engaging the process improvement groups might be unconventional but they provide leverage. The SEPGs are almost exclusively attended by industry practitioners concerned with organization software engineering practices and will have something to contribute to the definition of recommended individual practices.

### **12.3 IEEE RECOMMENDATION 3: Define Ethical Standards**

We recommend to study and customize, if necessary, existing codes already adopted by IEEE, ACM, registration boards, and other relevant organizations. It is not clear that we need something terribly different or specific to software on the grounds that the code of ethics of professionals building antennas, processors, or databases should be different. However, due perhaps to the rapid expansion of the field, software developers sometimes do things that might be considered unethical in other fields (e.g., indiscriminate copying of software in violation of copyrights or licenses.) This task should be charged to the Committee on Public Policy (COPP) of the Computer Society.

### **12.4 IEEE RECOMMENDATION 4: Define Educational Curricula**

We recommend the definition of curricula for (a) undergraduate, (b) graduate (MS), and (c) continuing education (for retraining and migration). This should be charged to an academic task force drawn from educational boards within the SEI, ACM and IEEE Computer Society, and relevant affiliate societies

There is a debate as to whether Software Engineering is a part of Computer Science or vice versa. We should not be distracted by this debate from the goal of meeting the needs of industry. The education needed by competent software engineers could be acquired in different ways. For example, we might identify the need for a foundation on statistics; at a given school, the courses could be offered by Computer Science, Software Engineering, or other departments. The objective is to seek agreement on the curricula that should be taught and not necessarily on which departments teach it.

## **APPENDIX A**

### **REFERENCES**

#### **1. CERTIFICATION**

American Society for Quality Control  
Computer P.O.Box 3005  
Milwaukee, WI 53201-3005  
(1-800-248-1946)

Institute for Certification of  
Professionals (ICCP)  
200 E. Devon Ave., Suite 268  
Des Plaines, IL 60018-4503  
(708-299-4227)

#### **2. REGISTRATION**

Institute of Electrical & Electronic Engineers, Inc.  
345 East 47th Street  
New York, NY 10017-2394

Software Quality Systems  
Registration Committee  
U.S. Registrar Accreditation Board  
611 East Wisconsin Avenue  
Milwaukee, WI 53202  
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#### **3. PUBLISHED MATERIAL**

Paper presented by Gary Ford, SEI Technical Staff, presented at 1993 SEI Software Engineering Symposium entitled, "The Current State of Certification & Licensing of Software Engineers"